COAL-MINE VENTILATION WITHOUT DOORS TO CONTROL MAIN AIR CURRENTS

By D. S. Kingery and E. J. Harris

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by

D. S. Kingery[2] and E. J. Harris[3]

SUMMARY

The practice of using doors to control main ventilating currents in bituminous-coal mines is common throughout the industry. When doors are erected in pairs to form air locks, they are usually accepted as satisfactory by both State and Federal coal-mine-inspection agencies.

A review of the contributing factors in recent methane ignitions showed that interrupted ventilation (often caused by doors latched open, destroyed, or damaged) was the principal cause of methane accumulations that subsequently were ignited.

The main purpose of this report is to show that coal mines can be ventilated without doors to control the main ventilating air currents and that such ventilating practice is best from the standpoint of efficiency, safety, and economy. The term "main air currents" does not apply to air after it has entered the section.

INTRODUCTION

Modern ventilation has been defined as "the first-line defense against methane ignitions." This concept necessitates a departure from previous concepts that based the quantity of air solely upon the number of men and animals employed and for which continuous air currents, or air splits ventilating two or more working sections, were considered adequate.

The evolution of coal-mine mechanization, with concentrated operations employing few men but rapidly exposing large areas of new coal faces and ribs, increases the problems of methane and coal-dust control. Consequently, modern ventilating systems should be based upon uninterrupted intake of enough air to sweep coal ribs and faces with a current that will render innocuous any methane emitted from the coal bed or surrounding strata.

A standard for such a requirement is covered in the Federal Coal Mine Safety Act under Ventilation.

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> Section 209(d). (2) If the air at an underground working face in a mine, when tested at a point not less than 12 inches from the roof, face, or rib, contains more than 1.0 per centum of methane, as determined by a permissible methane detector, a permissible flame safety lamp, air analysis, or other recognized means of accurately detecting such gas, changes or adjustments shall be made at once in the ventilation in such mine so that such air shall not contain more than 1.0 per centum of methane.
>
> (3) If a split of air returning from active underground working places in a mine contains more than 1.0 per centum of methane, as determined by a permissible methane detector, a permissible flame safety lamp, air analysis, or other recognized means of accurately detecting such gas, changes or adjustments shall be made at once in the ventilation in such mine so that such returning air shall not contain more than 1.0 per centum of methane.
>
> (4) If a split of air returning from active underground working places in a mine contains 1.5 per centum of methane, as determined by a permissible methane detector, a permissible flame safety lamp, air analysis, or other recognized means of accurately detecting such gas, the employees shall be withdrawn from the portion of the mine endangered thereby, and all power shall be cut off from such portion of the mine, until the quantity of methane in such split shall be less than 1.5 per centum. However, in virgin territory in mines ventilated by exhaust fans, where methane is liberated in large amounts, if the quality of air in a split ventilating the workings in such territory equals or exceeds twice the minimum volume of air prescribed in paragraph (1) of this subsection and if only permissible electric equipment is used in such workings and the air in the split returning from such workings does not pass over trolley or other bare power wires, and if a certified person designated by the mine operator is continually testing the gas content of the air in such split during mining operations in such workings, it shall be necessary to withdraw the employees and cut off all power from the portion of the mine endangered by such methane only when the quantity thereof in the air returning from such workings exceeds 2 per centum, as determined by a permissible methane detector, a permissible flame safety lamp, air analysis, or other recognized means of accurately detecting such gas.

To satisfy these requirements and assure maximum safety and minimum work stoppage due to inadequate ventilation, relatively large quantities of air may be necessary; in addition, the ventilating system must minimize the possibility of interrupted air currents and contaminated intake air.

A split system of ventilation, placing each gassy or potentially gassy section on a separate air split, is considered the best method of ventilating modern, mechanized, bituminous-coal mines.

Doors that separate intake and return airways cause substantial loss of air and, when latched open or damaged, interrupt ventilation. Doors also interfere with modern haulage and annually contribute to numerous haulage accidents and occasional fires.

Coal-mine ventilation is inefficient, even under the best possible conditions and maintenance of component parts. Comparisons of the volumes of air available at the working faces and those induced by fans often show losses of more than 75 percent. When the costs of fan installation, air shafts, numerous stoppings, air-course maintenance, power, and other direct ventilating costs are considered, it appears good business to assure success in return for this expenditure. Every aid that will reduce air leakage and pressure losses, reduce the possibility of contaminated air, and improve face ventilation is a good investment.

The elumination of doors by split ventilation usually requires overcasts or undercasts, with suitable regulation for the splits. The costs of such overcasts are often a deterrent to installing adequate systems of ventilation, particularly with development work where it is customary, even in very gassy mines, to ventilate two or more sets of developing entries with a single air split. Such practices mean that any methane picked up by the air currents in the first set of faces will be carried into the second development section. In gassy operations this contaminated air alone may make it difficult to satisfy requirements of the Federal Coal-Mine Safety Act. The fallacy of ventilating with a single air split is that too often the cost of overcast construction is not saved but only delayed until subsequent room-and-pillar recovery necessitates a separate air split. Delaying the construction of overcasts necessary for individual air splits has been responsible for several methane ignitions and a recent disastrous mine explosion. In this mine the overcast had been completed but not put into service when the explosion occurred.

Splitting air currents to provide a separate air split for each section proved the most efficient ventilating system at many mines that have changed from doors to individual split ventilation for each section. The costs of overcasts are partly absorbed, as better local control of the air is possible and air losses are reduced substantially. Less tangible savings result from improved haulage, improved ventilating efficiency, and greater safety.

Many bituminous-coal-mining companies, recognizing the economies to be derived from splitting air currents and the need for better and more positive face ventilation, have eliminated doors from their ventilating systems. However, in many otherwise progressive coal mines, little planning or engineering thought is devoted to ventilation until emergencies develop, after which expensive corrective action is necessary.

It is hoped that the information in this circular will prove valuable to officials, safety engineers, and mine employees and will point out that the common cliché, "ventilation doors are a necessary evil," should be changed to "ventilation doors are unnecessary,"

The illustrations and ventilating plans included in this paper are representative of ventilating systems in use throughout the bituminous-coal-mining field.

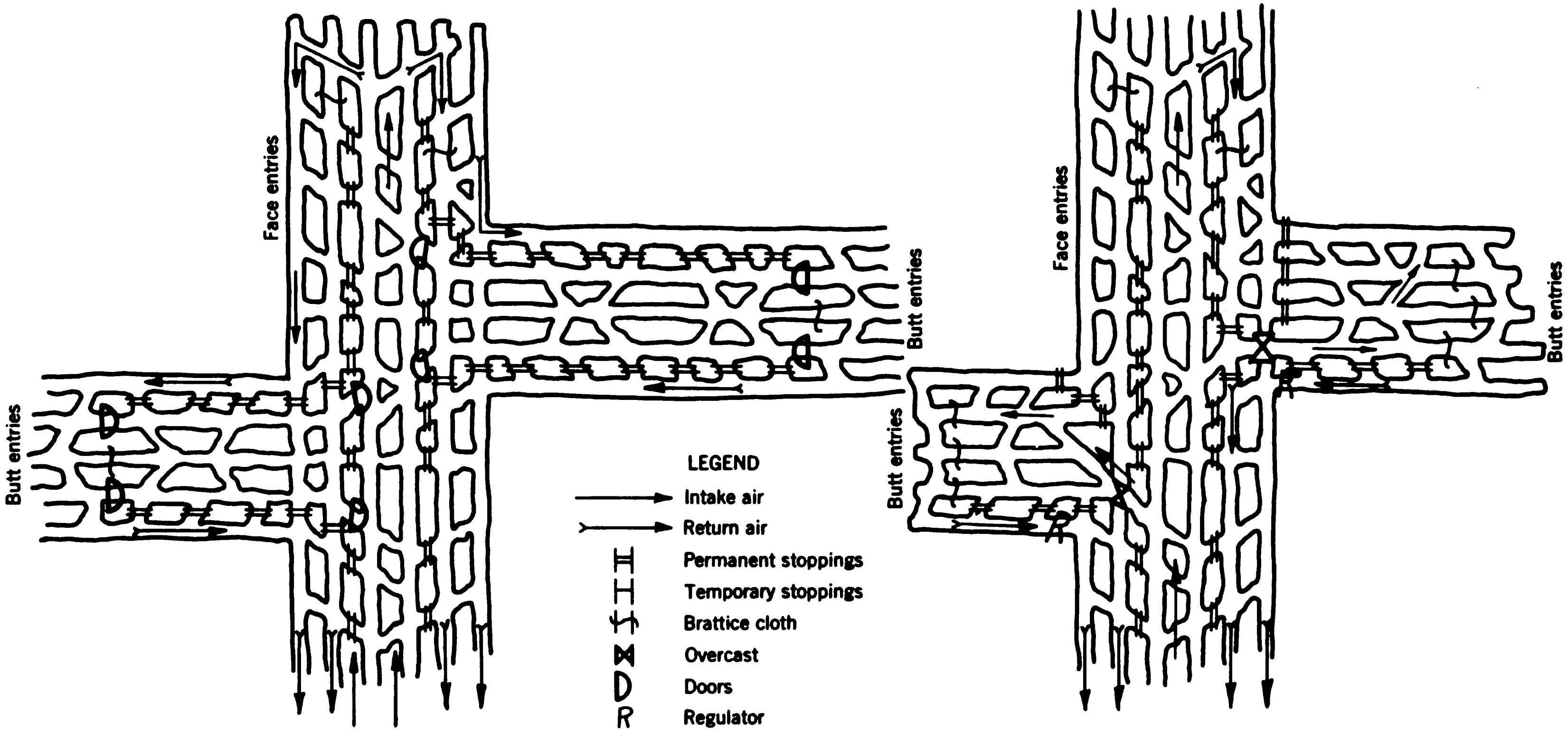
ACKNOWLEDGMENTS

Field work for this study was done by the authors at various bituminous-coal mines in Pennsylvania and West Virginia. Special acknowledgment is due officials of the cooperating mining companies, who permitted the use of ventilating plans and whose assistance made this study possible.

DISCUSSION OF VENTILATING PLANS

Mine A

Figure 1 shows a ventilating plan for development work that is used with variations throughout the bituminous-coal-mining industry.



A. – Ventilation plan using doors to control main ventilating currents

B. – Ventilation plan without using doors

FIGURE 1. - Mine A: Ventilating Plan for Development Work.

Illustration A shows the ventilation plan using doors to control the main ventilating currents. The intake air is carried up the two center face entries to the faces. After ventilating the faces the air is split; one part is used to ventilate the right and the other the left butt entries.

Doors are used to prevent short circuiting the intake air into the butt entries, and second doors are installed to form air locks near the butt faces. A check curtain is used in the shuttle-car haulage entry. This check curtain is the source of considerable leakage, and as two sets of air-lock doors are used the normal leakage loss for each butt entry is doubled. If abundant air is available, this leakage is beneficial because it adds intake air to the return air ventilating the section. However, if the quantity of air is barely adequate, the leakage from the four air locks may reduce the intake air available to the face entries below safe operating quantities. When an outby door is open in one of the four air locks, a substantial quantity of air is short-circuited through the butt-entry check curtain; a prolonged interruption could be serious to ventilating efficiency in the face entries and the opposite butt entries.

In addition to the air losses through leakage, circulation is handicapped by the distance that the air must travel as entries advance. This greater resistance creates greater loss of pressure, which in turn reduces the quantity of intake air available unless more pressure is introduced.

Illustration B shows how the mine could be ventilated without doors. The development plan is essentially the same, but one overcast is used with each set of butt entries. Intake air is carried up the two center face entries but is split at each butt entry; the face entries are the open split. This system assures that each set of entries will be ventilated by its own split of intake air and that leakage will be greatly reduced; moreover, by reducing both the distance of air travel and the velocity of the air, the system reduces pressure losses.

INDIVIDUAL SPLITS FOR PILLAR RECOVERY

Pillar lines that are operated from two or more sets of butt entries usually can be classified as continuous or stepped pillar lines.

The continuous pillar line is more difficult to ventilate without doors on the butt entries, owing to regulation difficulties. Changes in the return airways, in physical conditions at the face, or in gob or bleeder entries tend to alter the regulation balance, which in turn may cause inadequate ventilation at areas along the pillar line.

The stepped pillar line eliminates many of the ventilation-control problems of the continuous pillar line, as each set of butt entries can be readily ventilated by an individual split.

Mine B

Figure 2 shows individual splitting of a continuous pillar line. This ventilating plan is common where mobile loading machines and shuttle cars are used and, if the regulation balance is maintained, eliminates the need for doors on butt entries. Control and air balance was maintained through regulators placed in the back entry of each set of butt entries and intakes to the bleeder entry, which also served as a return entry. The butt-entry return airways served as equalizers for the bleeder return and as face returns. Full-length check curtains were used to deflect the air flow, and line brattice was used at the face where needed. The plan is flexible enough to permit modification and to suit most operating conditions.

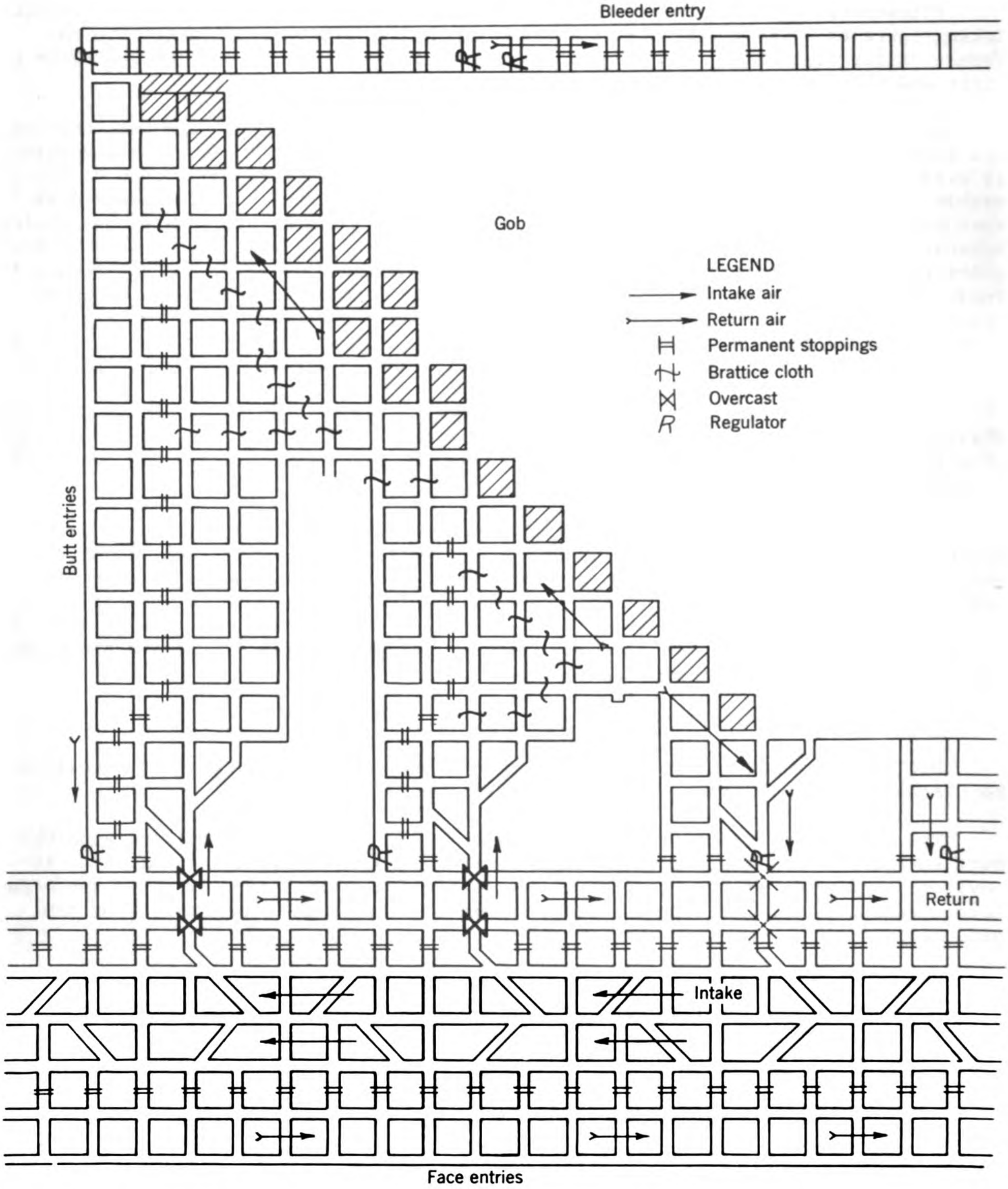


FIGURE 2. - Mine B: Individual Splitting of a Continuous Pillar Line.

Each butt entry carried a separate intake air split, which entered the pillar line and joined any residual air from the adjacent set of butt entries to sweep across the pillar faces.

Mine C

Figure 3 shows individual splitting of a stepped pillar line. This mine has three sets of operating butt entries. Intake air entered each set of butts and was deflected to the face by check curtains; after ventilating the pillar faces return air that had not entered the gob returned through the back entry of the adjacent set of operating butts. The bleeder entries served as supplementary return entries and were regulated at their junctions with main return air courses. Control was maintained by regulating each set of butt entries and the bleeder entries.

Mine D

Figure 4 shows the ventilating system of a large mine operating in a highly gassy West Virginia coal bed. At the time of the study the mine was in the development stage; however, as can be seen from the diagram, the mine management has projected an excellent ventilating plan using split ventilation and providing ample intake and return airways.

All development faces had available large quantities of intake air, the minimum being 36,000 cubic feet per minute. Intake air was carried through the center entries and, after ventilating the working faces, was returned through the outside entries; regulators were placed in the return entries outby the operating section.

The mine-development and ventilation plan designated the location of overcasts and stoppings. These were constructed as soon as possible during development. Air was controlled at the faces by temporary checks and line brattice.

This ventilating plan is not unusual; many progressive mining companies are adopting similar systems. The plan requires numerous overcasts and stoppings but will provide, if maintained, split ventilation during development and during room-and-pillar recovery. The system also pays dividends in reduced pressure losses and improved efficiency. The cost of overcasts may appear high, but when prorated against anticipated recovery of coal it is very moderate.

Mine E

Figure 5 shows the ventilating system used by a mine operating in a coal bed in southern West Virginia, where the methane emission in 24 hours was approximately 5 million cubic feet. A blowing system of ventilation was used; haulage roads were on intake air, and return air courses passed worked-out areas when possible.

All active and inactive sections were ventilated by separate air splits. The return air from working sections either entered gob areas or the return circuit through bleeder entries. With this ventilating arrangement the extensive gob areas, which because of the nature of the roof structures were relatively open, were used as parallel return air courses. The mine also used a 48-inch borehole as a supplementary upcast shaft.

The total quantity of intake air was approximately 411,000 cubic feet per minute. The minimum quantity of air available to active or inactive sections was about 30,000 cubic feet per minute. No doors were used to control ventilation.

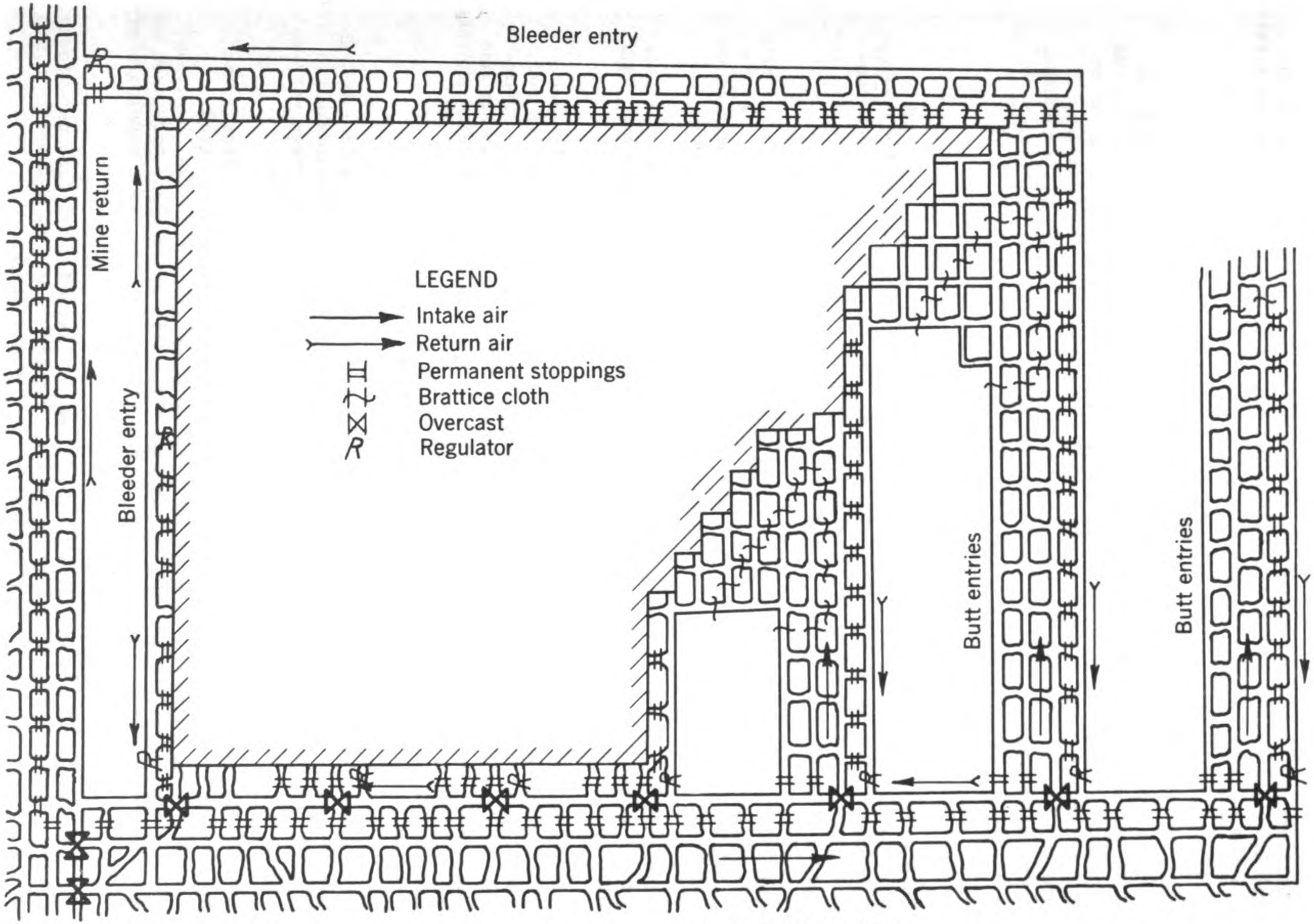


FIGURE 3. - Mine C: Individual Splitting of a Stepped Pillar Line.

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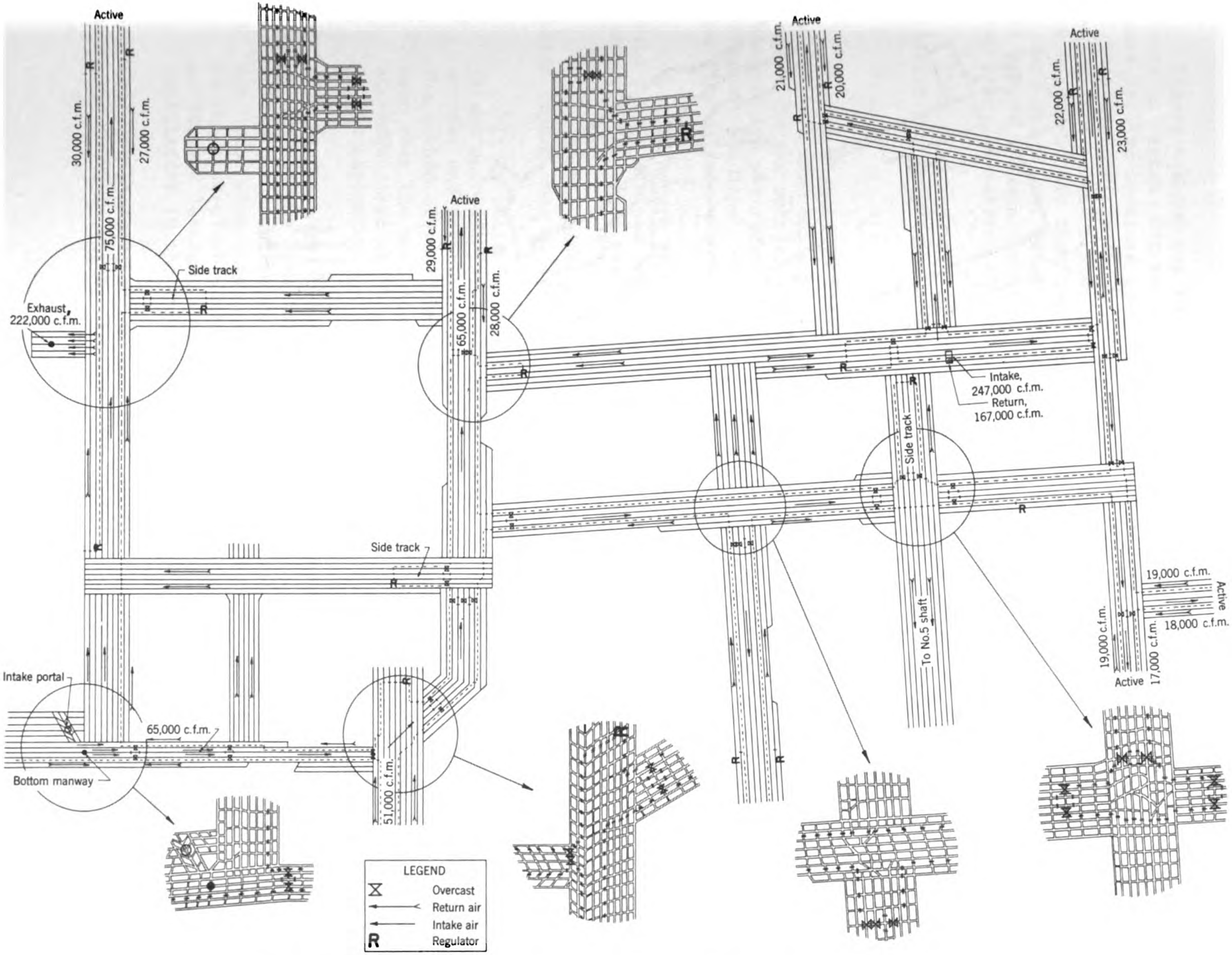

FIGURE 4. - Mine D: Ventilation System of Development for Large Mine.

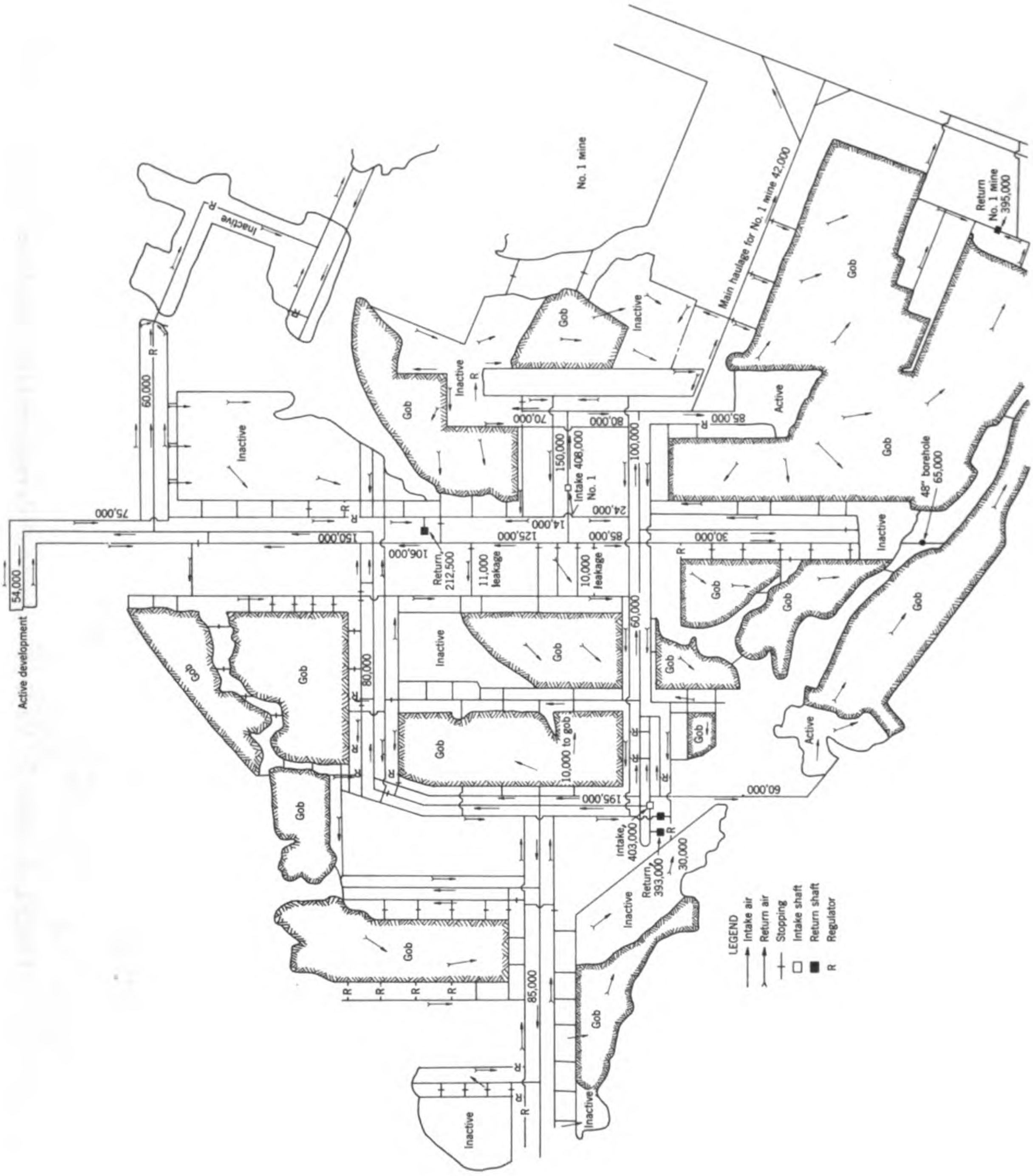

FIGURE 5. - Mine E: Line Diagram of Ventilating System for Large Mine.

Mine E

Figure 6 shows the ventilating plan of an operating section of the mine shown in figure 5. Intake air entered No. 5 butt entries and was controlled at the working faces by line brattice and check curtains. After ventilating the working faces, most of the intake air passed through the southeast corner of the gob to the south bleeder. In addition to the intake air entering the section, approximately 49,000 cubic feet per minute of air that had been used to ventilate development work was returned through No. 4 butt entries to the northeast corner of the pillared areas. The return air passed through the north bleeder and gob to the west and the south bleeder entries; from there it entered the return airways.

This plan provided intake air for mining operations, a bleeder system, and ventilation for worked-out areas.

Mine F

Figure 7 shows the ventilating plan of a new development section that was involved in a mine explosion. Illustration A shows how intake air traveled through several intake entries to a section adjacent to the new development area. Air from this section was returned through the back entries and used to ventilate the new development headings. Three doors, installed to form an air lock, were used to control the flow of intake air.

Shortly before the explosion the mine management had completed an overcast that would permit the new development section to be ventilated by a separate air split; however, the needed ventilating change had not been made.

The probable cause of the methane accumulation, as given in the disaster-investigation report, was as follows:

> It is believed that the intake air current was short circuited from the intake entries, particularly Nos. 5 and 6 returns inby the new development entries and from the working places in and off the new development entries. The method of ventilating the area and examination after the explosion indicate that the most logical explanation for such short circuiting is that the air-lock doors at the entrance to the section were open for some time previous to the explosion.
>
> Inasmuch as permanent or temporary stoppings were installed on both sides of the entries from the air-lock doors to the faces of the new development entries, a complete short circuiting of intake air to the return airways would not occur when these air-lock doors were opened. However, the excessive number of brattice-cloth stoppings in the new development entries would likely permit sufficient leakage, when the doors were open, to interfere seriously with face ventilation in the intake and new development entries.

This development section could easily have been ventilated by a separate air split, as shown in illustration B.

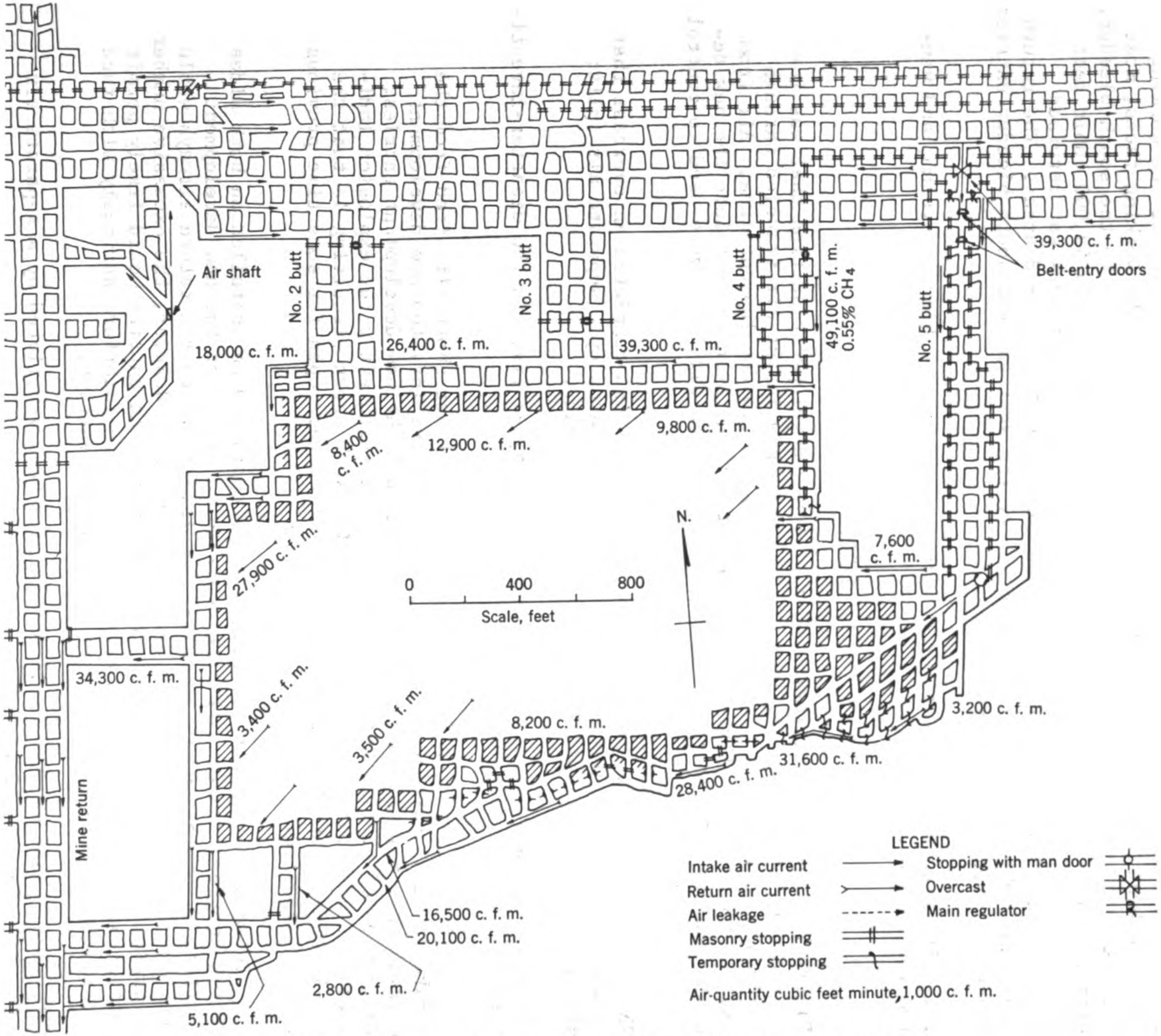

FIGURE 6. - Mine E: Ventilating Plan of Operating Section.

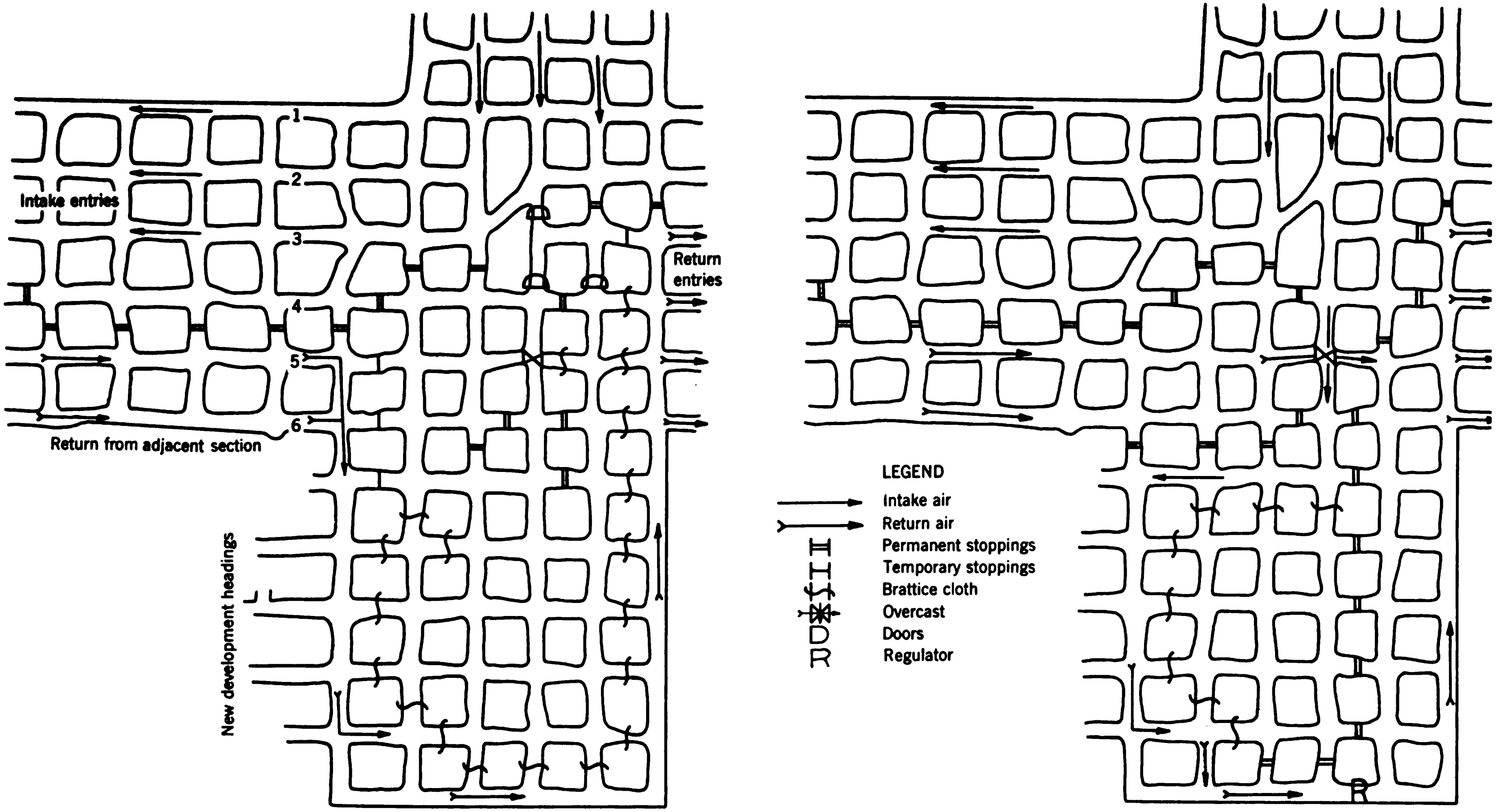

FIGURE 7. - Mine F: Ventilating Plan of New Development Section: A (Left); B (Right).

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